THE

SCIENTIFIC PROCEEDINGS

OF THE

ROYAL DUBLIN SOCIETY

VOL. 25 (N.S.).

No 10. FEBRUARY, 1950

SALMON OF THE DRUMCLIFFE RIVER

BY DENIS O'DRISCOLL.

DUBLIN:
PUBLISHED BY THE ROYAL DUBLIN SOCIETY,
BALLSBRIDGE, DUBLIN.
1950

Price: Three Shillings.

COMMONWEALTH MYCOLOGICAL INSTITUTE
1 MAR 1950

No. 10.

SALMON OF THE DRUMCLIFFE RIVER

By

DENIS O'DRISCOLL, B.Agr.Sc.,

Department of Agriculture, Fisheries Branch, Dublin.

[Read February 24, 1948. Published February 24, 1950.]

Communicated by Dr. A. E. J. Went.

The Drumcliffe River which enters Drumcliffe Bay, an arm of Sligo Bay, has a comparatively long flat estuary. About 4 miles upstream is Glencar Lough. This beautiful lake, about $1\frac{3}{4}$ miles long and scarcely more than 300 yards wide at any point, is hemmed in by the towering Sligo–Leitrim mountains, the Benbulbin range to the north being most impressive.

The main tributary of the Glencar Lough is the Diffreen River, a small spate stream, $3\frac{1}{2}$ to 4 miles long, originating in the mountains. There are a number of other small side streams entering the lake, but these are of no importance from a fishery viewpoint, as they are nothing more than torrents on the steep faces of the mountains in time of floods.

The rock underlying the catchment area of the Drumcliffe River, which is about 25 square miles, is limestone overlaid with glacial boulder-clay and alluvium, resulting in a relatively high alkalinity of the water (pH 8.2 to pH 8.4). It will be seen later that rapid growth in salmon parr can be correlated with this high pH value. In Fig. 1 the pH values of the water at selected points have been given, and Table 21 shows analyses of two samples of water, one each from the Drumcliffe River and Glencar Lough (see pages 122 and 123 for Tables).

Salmon run up the Drumcliffe River to Glencar Lough from February onwards each year, and are subject to capture in the estuary by means of draft nets. Spawning takes place both in the Drumcliffe and Diffreen Rivers, the fish dropping back from Glencar Lough in the case of the former.

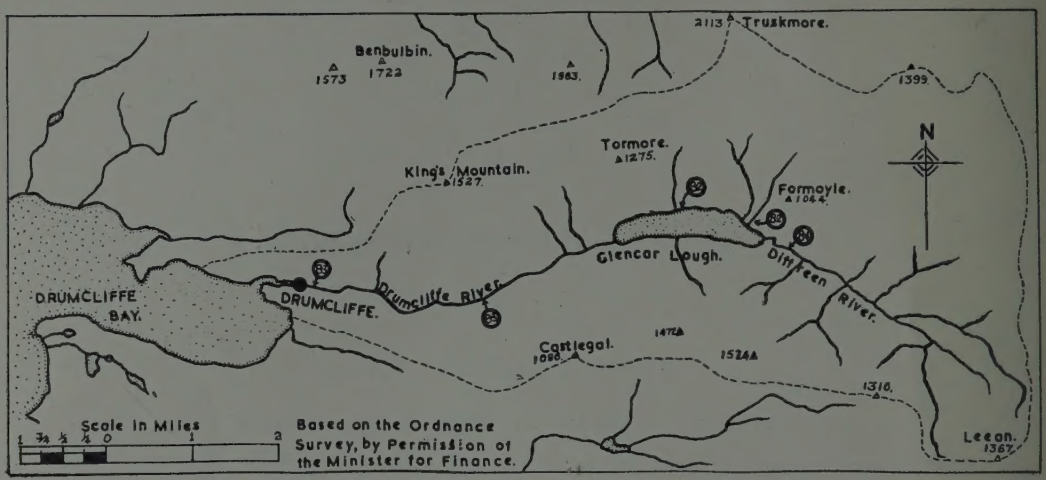

Fig 1. Sketch Map of the catchment area of the Drumcliffe River.

Material.—The material used in this investigation consisted of 528 sets of scales together with weights and measurements of salmon taken by draft nets in the tidal waters of the Drumcliffe River. During the years under investigation, 1942-1945 inclusive, 534 salmon were taken, from which 528 sets of scales, with satisfactory accompanying data, were obtained. Consequently, the material may be regarded as fully representative.

The legal season for netting the tidal waters of the Drumcliffe River extends from the 4th February to the 19th August, both days inclusive. Very few fish are taken before the first of March, or later than the middle of July. Of the 528 satisfactory sets of scales examined, 409, or almost four-fifths of the total, were from fish taken in 1942, 63 in 1943, 27 in 1944, and 29 in 1945. The years 1943, 1944 and 1945 were extremely poor in this river when compared with 1942. As will be shown later this was largely due to the almost complete absence of grilse in the latter 3 years. There were 180 grilse captured in June and July of 1942 while there were only 3 taken in June, 1943, and none in either 1944 or 1945.

Methods.—The fish were weighed and measured from the tip of snout to the fork of the tail. The measurements were recorded to the nearest tenth of an inch, and the weights to the nearest ounce.

Smolt Ages.—The percentage distribution of the smolt ages in each group is given in Table 1. The majority of fish migrated as one-year or two-year smolts (over 99.5 per cent.). The percentage of one-year smolts was 23.7, a figure which may be termed high but of the same order as those obtained for the Ballisodare River (Went, 1941) and the River Shannon (Went, 1938).

Smolt Types.—As described in previous publications on Irish Salmon (Went 1938-1944) some salmon show on their scales evidence of freshwater growth during the spring of the year in which migration to the sea as smolts took place. Others show little or no such growth, and these are designated Type A smolts, while those that show an appreciable amount (more than two annuli or growth rings) are classified as Type B smolts. The estimated percentage of the different smolt types in each smolt class is recorded in Table 14, where it may be seen that Type A and Type B are represented by 13.4 per cent. and 86.6 per cent. of the total, respectively. Almost two-thirds of the fish examined belonged to the two-year (Type B) class.

Age Goups.—Unspawned or maiden salmon in the Drumcliffe River fall into three main groups, namely grilse (1 + winters), small spring fish (2 winters), and small summer fish (2 + winters). The proportions of large spring fish (3 winters) and large summer fish (3 + winters) are small, as is also that of previously spawned fish.

The proportion of each group is given below, for the four years 1942-1945 and for 1942 alone, as the latter year would appear to be more normal than the others, as we have seen above, with a fairly good run of fish on into July.

		Age Groups (in sea winters)						Total
		1+	2	2+	3	3+	With S.Ms.	
Percentage (numerically)	1942–45	34·6	33·8	28·2	0·4	0·2	2·8	100
	1942	44·1	29·9	22·8	0·25	0·25	2·7	100

This shows a fairly even distribution between the 3 main groups, and taking 1942, if we consider that the small summer fish weigh, on the average, about twice the average weight of the grilse, with the small spring fish slightly less, it is clear that, taking weight as the standard, all three classes are almost equal. The advantage is slightly in favour of the spring fish. The percentages by weight, for 1942 may be seen in Table 3.

Table 2 gives the percentages of each age group in the catch of each month. In March over 90 per cent. of the fish taken are spring fish. In April 74 per cent. are spring fish, while 20 per cent. are summer fish. By May the balance has swung in favour of summer fish, 56 per cent. as against 40 per cent. spring fish. In June grilse (77 per cent.) predominate, with small summer fish almost 17 per cent., and small spring fish down to 4 per cent. In July the catch was almost completely composed of grilse.

In Table 4, grilse and small summer fish combined as " summer fish," comprise 63·5 per cent. of the total with " spring fish " giving 36·5 per cent.

The percentage of the total of each age group in each month is given in Table 5. From the totals for each month it may be seen that May and June are the two best months, and both, being about evenly represented, 34·8 per cent. and 32·9 per cent., respectively, provide two-thirds of the total catch, while the remainder are fairly evenly divided between March, April, and July, with a few in February.

As stated above the number of fish with spawning marks on their scales is small, being only about 2·8 per cent. in the four years 1942-45. No fish had more than one spawning mark on its scales. Of the fifteen previously spawned fish whose scales were examined, 7 had entered the river originally as grilse, 5 as small summer fish, and 3 as small spring fish. These figures cannot be claimed to be absolutely accurate since it is not always possible, due to varying degrees of erosion of the scales, to say to what age group a previously spawned fish belonged when first returning to spawn.

Previously spawned fish are classified according to their " absence habit," *i.e.*, the period spent in the sea from the time of their return as kelts after spawning to the time of re-entry to the river to spawn again. The " short absence habit " involves a stay of less than a year, often only a few months, the " long absence habit " extends for a period of a year, and the " very long absence " for more than a full year. As will be seen from Table 7, the three classes are fairly evenly represented.

Divided Migration and Return.—Table 6 shows divided migration and return referred to the year 1942. It may be seen that over nine-tenths of the stock of returning salmon depend on the fry hatched three or four years earlier. This, naturally, follows from the fact that (i) the bulk of the smolts migrate as either one- or two-year-olds, and (ii) the vast majority of the salmon return as grilse (1+ winters), or as small spring or small summer fish (2 or 2+winters), respectively.

Size Distribution.—Table 8 gives the calculated frequency distribution in class intervals of one inch, the bulk of the fish lying between 21·95 and 33·95 (class intervals 22 and 33).

Average Sizes.—Monthly details of average weight and length for the three main classes, viz., grilse, small spring fish, and small summer fish, are included in Table 9, from which the relevant details have been extracted.

(1) *Grilse* (1+*winters*).—The number examined was 183. Of these 180 were taken in 1942, when numerically they comprised over 44 per cent. of the catch.

	lb.	inches.	Date of Capture.
Minimum	$3\frac{1}{8}$	19·5	2/6/42
	3	20·1	10/6/42
Average	6·3	24·0	—
Maximum	11·0	29·0	24/6/42

In 1942 the first grilse was captured on the 2nd June. As the season advanced grilse became longer, and this increase in length was accompanied by a more than proportional increase in weight, resulting in a heavier and superior conditioned fish, as will be seen from the following Table:

	First half of June.	Second half of June.	July (to 20th).
Number examined	40	91	49
Average weight (lb.)	5·67	6·31	7·2
Average length (in.)	23·4	23·8	24·5
Condition Co-efficient (K) ...	1·19	1·24	1·27

(2) *Small spring fish* (2 *winters*).—Total number examined=179.

	lb.	inches.	Date of Capture.
Minimum	5	24·25	16/3/42
	5	23·5	17/3/42
Average	10·9	29·7	—
Maximum	$17\frac{1}{8}$	32·6	15/4/42
	$16\frac{5}{8}$	32·8	11/5/42

The fish taken on the 16th March, weighing 5 lb. and measuring 24·25 inches was in poor condition, being one of the very few fish recorded whose condition co-efficient (K.=0·97) was less than 1·00. Fish of the two-year smolt class were, on the average, smaller than those of one-year smolt class, as will be seen from Table 9. A similar condition was noted in the salmon of the Ballisodare River (Went 1941).

(3) *Small summer fish* (2+*winters*).—Total number examined=148.

	lb.	inches.	Date of Capture.
Minimum	$7\frac{3}{4}$	27·7	18/3/42
Average	13·1	31·2	—
Maximum	$21\frac{3}{4}$	36·5	21/5/42
	$21\frac{1}{4}$	37·0	24/5/42

During the four years under observation only a few isolated specimens of this class appeared before the 20th April in any year.

(4) *Large spring fish* (3 *winters*).—Only two salmon of this age group were taken in the years in question. One, taken on the 30th April, 1942, weighed $23\frac{1}{2}$ lb. and was $38\frac{1}{4}$ inches in length; it was the largest fish taken over the period under review. The second large spring fish was recorded for the 10th March, 1943, and weighed $15\frac{1}{8}$ lb., being 32·9 inches long.

(5) *Large summer fish* (3+*winters*).—Only one fish of this class was recorded—on the 2nd June, 1942. It weighed $19\frac{1}{4}$ lb., and was 35·3 inches long.

Table 1. Percentage of each smolt age in each age group in years 1942 to 1945.

Smolt Age	Age Group						Total (maiden fish)
	1+	2	2+	3	3+	S.Ms.	
One year	15.3	30.7	32.0	-	100.0	13.33	23.7
Two years	84.7	68.7	67.3	100.0	-	86.67	75.9
Three years	-	0.6	0.7	-	-	-	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 2. Percentage of each age group in the catch of each month.

Month	Age Group							Total
	1+	2	2+	3	3+	S.Ms. Spring	S.Ms. Summer	
Feb.	-	50.0	-	50.0	-	-	-	100.0
Mar.	-	91.0	7.5	-	-	1.5	-	100.0
April	-	74.0	20.0	2.0	-	2.0	2.0	100.0
May	-	40.0	56.1	-	-	1.7	2.2	100.0
June	77.4	4.0	16.8	-	0.6	-	1.2	100.0
July	98.1	-	0.5	-	-	-	1.4	100.0
Total	34.6	33.8	28.2	0.4	0.2	0.9	1.9	100.0

Table 3. Percentage composition of 1942 catch (A) Numbers, (B) Weight.

Winters in Sea	(A) Numbers						(B) Weight					
	1+	2	2+	3	3+	S.Ms.	1+	2	2+	3	3+	S.Ms.
% of 1942 catch	44.1	29.9	22.8	0.25	0.25	2.7	30.2	33.6	31.2	0.4	0.5	4.1

Table 4. Percentage of spring and summer fish in each month's catch.

Month	Spring Fish	Summer Fish
Feb. & Mar.	97.1	2.9
April	78.0	22.0
May	41.7	58.3
June	4.0	96.0
July	-	100.0
Total	35.1	64.9

Table 5. Percentage of total of each age group in each month.

Month	Age Group						Total
	1+	2	2+	3	3+	S.Ms.	
Feb.	-	0.6	-	50.0	-	-	0.4
March	-	34.1	3.4	-	-	6.7	12.4
April	-	21.0	6.7	50.0	-	13.3	9.5
May	-	40.3	68.7	-	-	46.6	34.8
June	73.3	4.0	20.4	-	100.0	13.3	32.9
July	26.7	-	0.7	-	-	20.1	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6. Showing Divided Migration and Return.

Returned in 1942 as	Hatched in the year					Total
	1936	1937	1938	1939	1940	
Grilse (1+)	-	-	-	28.3	6.3	34.6
Small Spring Fish (2)	-	0.2	19.8	13.8	-	33.8
Small Summer Fish (2+)	-	0.2	19.0	9.0	-	28.2
Large Spring Fish (3)	-	0.4	-	-	-	0.4
Large Summer Fish (3+)	-	-	0.2	-	-	0.2
Previously Spawned (S.Ms.)	0.9	1.3	0.4	0.2	-	2.8
Total	0.9	2.1	39.4	51.3	6.3	100.0

Table 7. "Absence Habit" of Previously Spawned Fish.

Absence	No.	%
Short (less then one year)	4	26.7
Long (a full year)	5	33.3
Very Long (more than a full year)	6	40.0

Table 8. Calculated frequency distribution of lengths in different age groups for the years 1942-1945.

Length in inches	Age Group						All Ages
	1+	2	2+	3	3+	S.Ms.	
19	1	-	-	-	-	-	1
20	6	-	-	-	-	-	6
21	6	-	-	-	-	-	6
22	20	-	-	-	-	-	20
23	45	1	-	-	-	-	46
24	52	2	-	-	-	-	54
25	31	4	-	-	-	-	35
26	17	4	1	-	-	-	22
27	2	9	3	-	-	1	15
28	2	31	11	-	-	-	44
29	1	53	22	-	-	-	76
30	-	38	30	-	-	2	70
31	-	19	39	-	-	3	61
32	-	13	15	1	-	5	34
33	-	4	13	-	-	1	18
34	-	1	6	-	-	1	8
35	-	-	4	-	1	1	6
36	-	-	3	-	-	-	3
37	-	-	1	-	-	1	2
38	-	-	-	1	-	-	1
Total	183	179	148	2	1	15	528

Table 9. Mean weights (lb.), lengths (inches) and condition co-efficient (K) of the different groups in various months.

Month	Years in River						Total		
	One			Two					
	Weight	Length	K.	Weight	Length	K	Weight	Length	K
(a) Grilse (1+)									
June	6.1	24.0	1.21	6.1	23.8	1.23	6.1	23.9	1.23
July	7.5	24.4	1.31	7.1	24.6	1.26	7.2	24.5	1.27
Total	6.4	24.1	1.23	6.4	24.0	1.24	6.3	24.0	1.24
(b) Small Spring Fish (2)									
March	9.3	28.5	1.10	10.0	28.9	1.14	9.8	28.8	1.13
April	11.6	30.2	1.16	11.5	30.2	1.16	11.6	30.2	1.16
May	11.4	30.1	1.15	11.2	30.0	1.14	11.3	30.0	1.14
June	14.6	32.2	1.21	11.2	30.3	1.11	12.2	30.9	1.14
Total	11.1	29.8	1.14	10.8	29.6	1.14	10.9	29.7	1.14
(c) Small Summer Fish (2+)									
March & April	11.7	30.3	1.16	11.0	29.6	1.15	11.2	29.9	1.16
May	12.8	31.1	1.18	13.3	31.1	1.20	13.1	31.1	1.19
June & July	13.1	31.8	1.14	14.0	32.2	1.20	13.8	32.1	1.18
Total	12.7	31.1	1.17	13.3	31.3	1.20	13.1	31.2	1.18

Table 10. Mean condition co-efficients (K) and condition factors (C.F.) in each age group.

Age Group	1+ Winters	2 Winters	2+ Winters	With S.Ms.	Spring Fish	Summer Fish
K.	1.24	1.14	1.18	1.18	1.14	1.21
C.F.	44.6	41.0	42.4	42.4	41.0	43.6

Table 11. Average monthly condition co-efficients (K) and condition factors (C.F.)

Month	March	April	May	June	July	All Fish
K.	1.11	1.16	1.17	1.22	1.27	1.19
C.F.	40.0	41.7	42.1	43.9	45.7	42.7

Table 12. Calculated growth in fresh water in different smolt classes.

Smolt Age	No.	Average Length in inches			Average smolt length in inches
		1st year	2nd year	3rd year	
1	131	2.61	-	-	4.35
2	380	1.62	4.12	-	4.89
3	2	1.25	2.40	4.50	4.50

Table 13. Calculated average length in inches at end of each winter of river and sea life.

Group	No. of Fish	River Life			Sea Life		
		1	2	3	1	2	3
1.1+	28	2.87	-	-	17.78	-	-
2.1+	155	1.61	4.00	-	17.74	-	-
1.2	55	2.55	-	-	17.84	29.84	-
2.2	123	1.77	4.28	-	18.05	28.94	-
3.2	1	1.00	2.10	3.80	15.40	25.50	-
1.2+	47	2.40	-	-	17.77	28.89	-
2.2+	100	1.70	4.16	-	18.29	28.92	-
3.2+	1	1.50	3.70	5.20	18.80	28.80	-
2.3	2	1.55	4.00	-	17.10	29.85	35.60
1.3+	1	2.40	-	-	15.50	21.20	32.60

Table 14. Estimated proportion of the different smolt types in each smolt class for maiden fish.

Smolt Age	Type A Smolts	Type B Smolts	Total (Maiden Fish)
One year	-	23.7	23.7
Two years	13.2	62.7	75.9
Three years	0.2	0.2	0.4
Total	13.4	86.6	100.0

Table 15. Calculated lengths for the different smolt types in the one and two year smolt classes.

Smolt Class	Growth Type					
	A			B		
	Length at end of		Length of Smolts	Length at end of		Length of Smolts
	1 year	2 years		1 year	2 years	
1 year	-	-	-	2.61	-	4.35
2 year	1.89	4.61	4.61	1.57	4.02	4.94

Table 16. Calculated mean lengths in inches at end of each winter in the sea in the various Age Groups.

Age Group	Number Examined	Length of Smolts	Sea Life			Length at Capture
			1st Year	2nd Year	3rd Year	
1+	183	4.83	17.7	-	-	24.0
2	179	4.72	18.0	29.7	-	29.7
2+	148	4.82	18.1	28.9	-	31.2
3	2	5.1	17.1	29.8	35.6	35.6
3+	1	4.1	15.5	21.2	32.6	35.3

Table 17. Average growth increment (I) in inches made in final summer in grilse and small summer fish for year 1942.

Month	Grilse (1+ Winters)		Small Summer Fish (2+ Winters)	
	Number Examined	Increment	Number Examined	Increment
April	-	-	9	1.3
May	-	-	70	2.0
June	131	6.2	12	3.5
July	49	6.8	1	2.5
Mean	180	6.3	92	2.1

Table 18. Correlation between lengths at end of first winter (L_1) and second winter (L_2) in fresh water for the two year smolt class.

Length at end of 1st winter in inches. L_1	No.	Average length at end of second winter in inches. L_2	Average Increment made in second season in inches.
0.95-1.45	117	3.64	2.44
1.45-1.95	157	4.07	2.37
1.95-2.45	82	4.62	2.42
2.45-2.95	16	5.13	2.43

Table 19. Correlation between Smolt Length and Length at end of First Sea Winter for Grilse.

Smolt Size in inches.	Number of Individuals.	Mean Length in inches at end of 1st Sea Winter.	Mean Increment in inches during 1st Season of Sea Life.
3.0-3.4	2	17.2	14.0
3.5-3.9	7	17.1	13.4
4.0-4.4	34	17.2	13.0
4.5-4.9	64	17.9	13.2
5.0-5.4	51	17.8	12.6
5.5-5.9	21	19.0	13.3
6.0-6.4	3	17.4	11.2
6.5-6.9	1	20.3	13.8

Table 20. Correlation between Lengths of the Grilse at the end of the First Sea Winter and time of Capture.

Length at end of 1st Sea Winter in ins.	Mean Length at time of Capture.	Mean Increment	Number of Individuals
14-14.9	19.5	4.6	1
15-15.9	21.2	5.7	8
16-16-9	23.3	6.8	33
17-17.9	24.0	6.5	63
18-18.9	24.8	6.3	50
19-19.9	25.5	6.0	23
20-20.9	26.0	5.7	3
21-21.9	26.0	4.7	2

Table 21. Analyses of Waters from Glencar Lake and Drumcliffe River in parts per million (i.e. milligrams per litre)

	Drumcliffe River about ½ mile from mouth.	Glencar Lake about midway on North side.
Dissolved Solids		
Total	150.0	157.0
Fixed	120.0	128.0
Volatile	30.0	29.0
Chlorine (Cl.)	15.0	15.0
Silica (SiO_2)	1.0	1.0
Iron (Fe_2O_3)	<0.1	0.1
Calcium (CaO)	60.0	60.7
Magnesia (MgO)	7.0	7.0
Sodium (Na_2O)	11.0	16.0
Potassium (K_2O)	1.7	1.9
pH	8.0	8.0
Date of Sampling	1/10/1947	1/10/1947

(6) *Previously spawned fish (with S.Ms.).*—This group of fish cannot be classified according to age, as the age and migration habits of the individuals included in it may vary considerably, but all possess the one common characteristic, namely, a spawning mark on the scales. As already mentioned, the fish in this group are merely classified (i) where possible, age at first spawning, (ii) absence habit—Table 7.

The following are the largest and smallest fish included in this Class :—

	lb.	inches.	Date of Capture.
Maximum	21¾	37·5	15/5/42
Minimum	9	27·0	16/6/42

The largest fish exhibited the " very long " absence habit after entering the river originally as a small spring or small summer fish, probably the latter. Since it had spent two parr years in the river before migration, this fish would be over six years old when captured. Exhibiting the short absence habit, the smallest fish, which had originally returned to the river as a grilse, also migrated as a two-year smolt and, consequently, would be two years younger than the largest fish. All the fish of this group had spawned only once previously.

Condition Co-efficient (K).—The Condition Co-efficient (K) or the relationship between weight and length is determined according to the formula $K=W/(L^3 \times 0{\cdot}00036)$ where W=weight in lb. and L=length in inches. The formula gave a figure approximating to unity for normally fed fish in Scottish rivers for which it was devised (Menzies 1921). Another method of expressing the relationship between weight and length is by the Condition Factor (C.F.), according to Corbett's scale, $(C.F.=100{,}000\ W/L^3$, where W=weight in lb. and L=length in inches. The relationship between the values is obviously C.F.=K x 36.

The main value of the condition co-efficient for all the fish in this investigation was 1·19, which is approximately that recorded for the nearby Ballisodare River and for the River Erne. Two other items of similarity with Ballisodare are afforded by the fact that the summer fish are superior in condition to the spring fish, and that there is a gradual rise in the monthly average from March to July. Comment has already been made on the appreciable rise in condition co-efficient among the grilse throughout June and July of 1942, culminating in a mean value of 1.27 for 49 grilse taken in July of that year.

Erosion of Scales.—This phenomenon is said to be due to the absorption of the substance of scales, beginning with the edges, when the gonads of the salmon are ripening. It takes place usually in fresh water, but fresh-run salmon are often met with having their scales eroded to a considerable degree, possibly due to some delay in passage from sea to river. In May and June of 1942, of the small spring and small summer fish taken in those months, 11 per cent. (average erosion 3° on Menzies scale), and 14 per cent. (average erosion 1·9°), respectively, bore eroded scales. The corresponding figures for 1943 were 40 per cent. of spring fish (average erosion 3·5°) and 8 per cent. summer fish (average erosion 2°) with eroded scales in May and June.

Calculated lengths.—The length of each unspawned or "maiden" fish, at the end of every year of its life, together with its smolt length, was calculated in the usual way, *i.e.*, on the assumption that the growth of the scale was directly proportional to the growth of the fish. The calculated average length at the end of each winter of river and sea life is given for the various age groups in Table 13.

(A) *River Life.*—In this section the relationship between the lengths of the parr at the end of each year in the river are the subject for discussion. From Table 12, it is obvious that those fish which migrated as one-year smolts made, in their first year, the most rapid growth. Likewise, the two-year smolt class was, on the average, longer than the three-year smolt class at the end of the first and second years.

The growth rate of the three smolt classes is illustrated graphically in Fig. 2A. Percentage frequency distribution curves for the one and two-year smolt classes are given in Fig. 2B.

The calculated lengths for the different smolt types in the one- and two-year smolt classes are given in Table 15. The appropriate growth curves are given in Fig. 3A and the frequency distribution curves in Fig. 3B. It is evident from these figures and diagrams that the fastest growing fish are the one-year Type B smolts, followed by the two-year Type A smolts with the two-year Type B smolts the slowest. In Fig. 3B, in which the frequency distribution curves of the various growth types at different periods of life are plotted, it may be seen that the advantage in size which the two-year Type A smolts possess over the two-year Type B smolts is already manifest when these fish are only one year old.

In the scales of those fish that migrated as Type B smolts it is possible to differentiate between the freshwater and sea growth. Thus it is possible to calculate the smolt length in Type B as well as in Type A smolts; the results being given in Table 15. The mean smolt length for all smolt types is 4·75 inches.

These results are in keeping with conditions found in other Irish rivers (Went 1938-1946). Went has suggested that the parr must attain some physiological condition, associated, at least as an index, with a minimum size, before smolt migration takes place. In the Drumcliffe River the minimum size would appear to be about 3·3–3·4 inches, a figure appreciably lower than the figures for the other rivers. Thus, it would appear that, while the fastest growing smolts migrate earliest and the attainment of a minimum size seems a prerequisite qualification, the size which must be attained varies considerably from river to river. Under such circumstances the number of smolts reared in different rivers would not necessarily be proportional to the amount of food present. The maximum smolt output (in numbers per unit food) would be much higher in rivers where migration takes place at a smaller size.

In Table 16 the calculated lengths of every age group and smolt class are given.

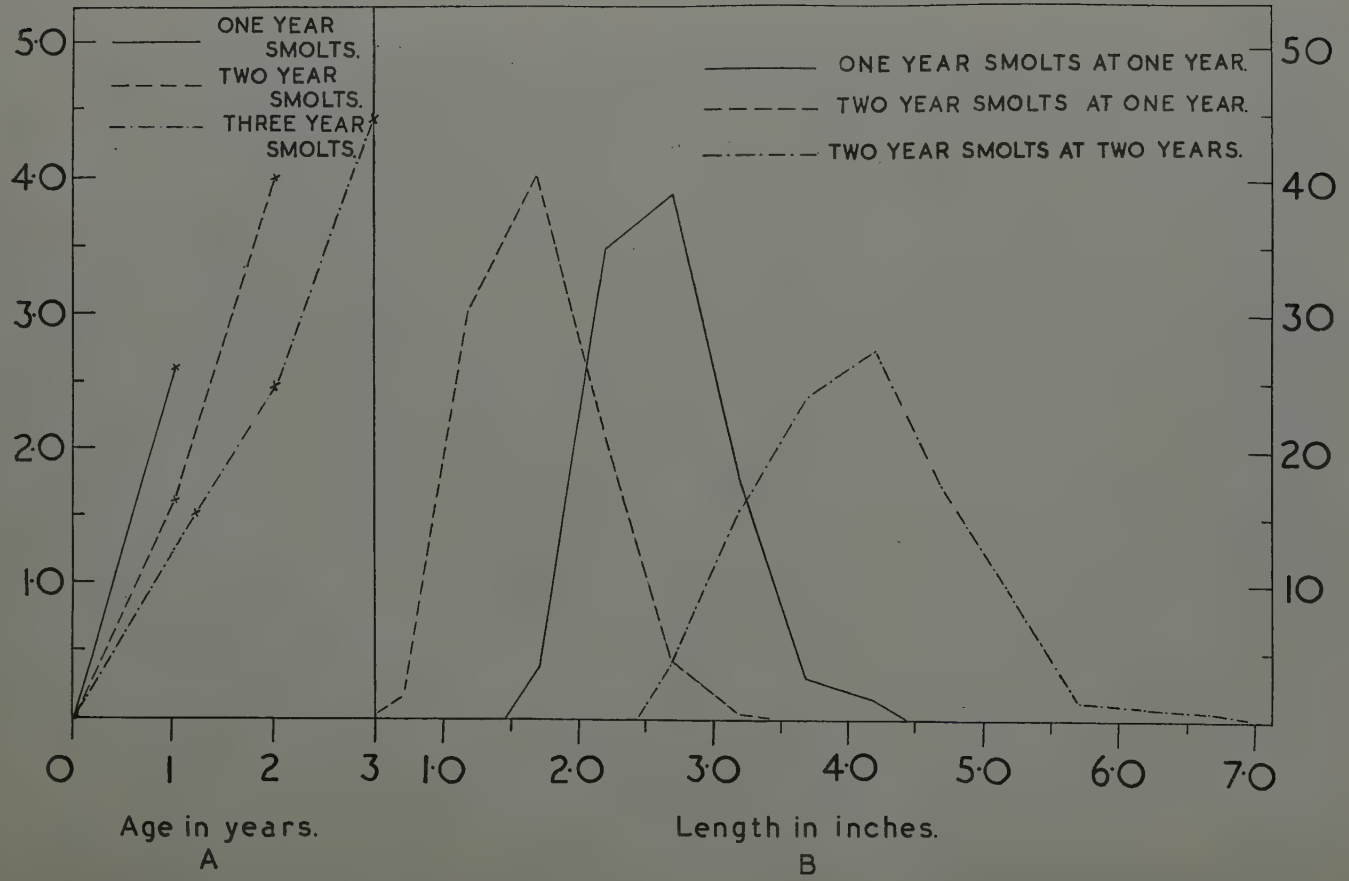

Fig 2. A. Growth curves for the various smolt classes in fresh water. B. Frequency distribution curves for the various smolt classes at different ages.

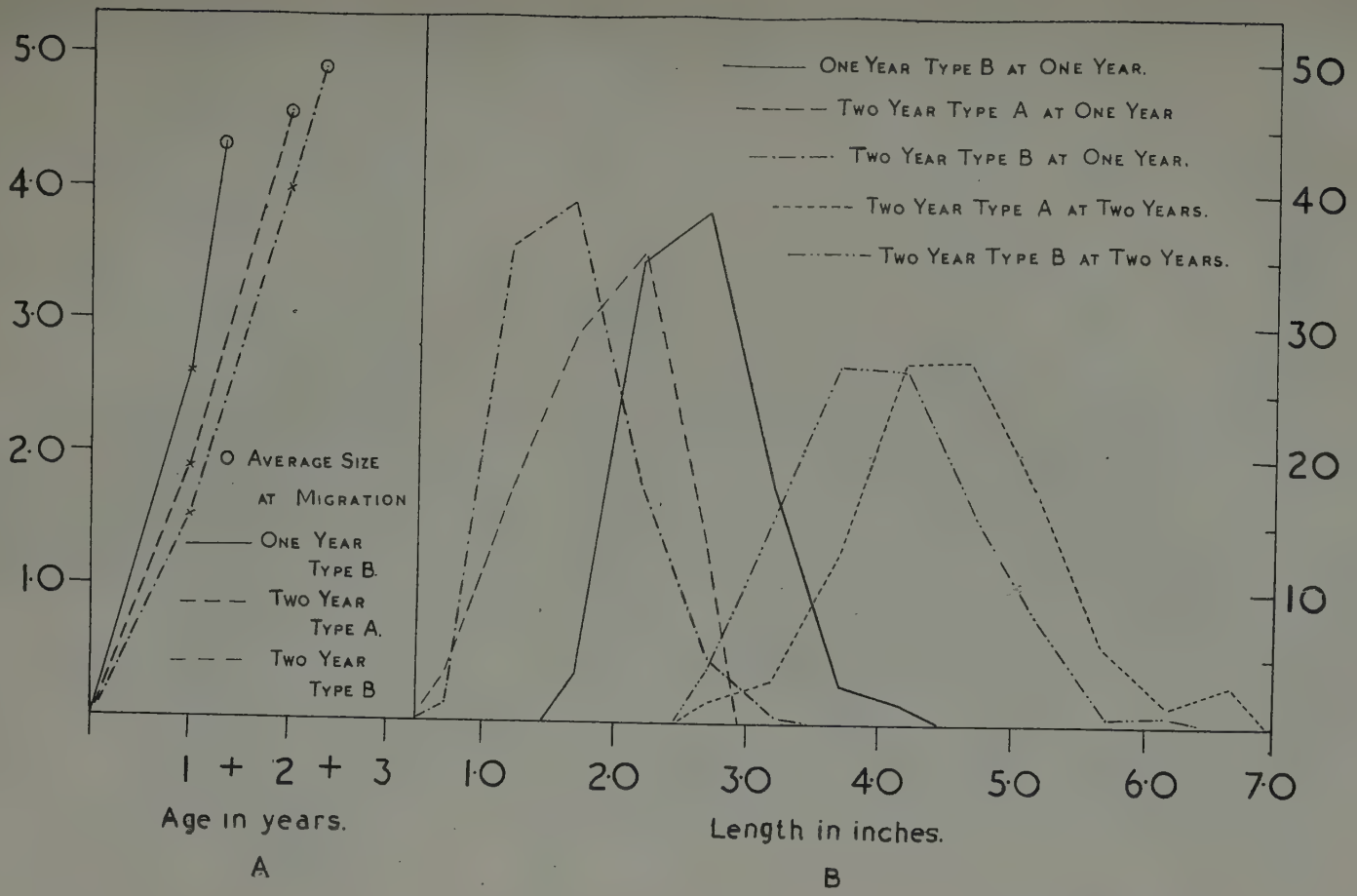

Fig 3. A. Growth curves for the various smolt types. B. Frequency distribution curves for the various smolt types.

(B) *Sea Life.*—The calculated lengths for each year of sea life for the various age groups are given in Table 16. At the end of the first year, the average length for the grilse is lower than that for the small spring and small summer fish. At the end of the second year the small spring fish are longer, on the average, than the small summer fish.

The calculated average growth increments made in the final summer by grilse and small summer fish are given in Table 17. As would be expected, these increments show an increase as the season progresses, and also the mean increment in the grilse is much higher than that in the small summer fish. This difference is probably due mainly to the fact that the bulk of the latter are taken in May, while the main run of grilse is not until June or July.

(C) *Correlation Tables.*—(1) Correlation between parr lengths at the end of the first and second winters in the river is given in Table 18. The average increment during the second season is about 2·4 inches with no definite relationship between the length at the end of the second year and that increment.

(2) Correlation between smolt length and length at end of the first sea winter for grilse is shown in Table 19. It will be seen that the larger smolts produce the larger fish at the end of the first sea winter, but the growth increment during the first sea winter decreases with an increase in smolt length.

(3) Correlation between lengths of grilse at the end of the first sea winter and at time of capture is shown in Table 20. Fish belonging to the 16, 17 and 18-inch groups at the end of the first sea winter show the largest increments during the final summer previous to capture. We have already seen that fish taken late in the season have a greater increment than those taken earlier, and consequently these late fish should provide a fairly even run, being drawn from the middle size groups, with a greater variation in size occurring among fish taken earlier in season. This is in accordance with the facts observed. A similar situation was observed on the Ballisodare River (Went 1941).

Notes on the Growth of Brown Trout in Glencar Lough and Drumcliffe River.

Material for this section was provided by sets of scales and measurements from 55 brown trout captured in these waters, mostly during the second half of 1941. 44 of the trout were taken from Glencar Lough, and 10 from the Drumcliffe River. Lengths at the end of each year were calculated in the usual manner, *i.e.*, on the assumption that the growth of the scale was proportional to the growth of the fish. All the trout taken were young, none being fully 4 years of age. One was less than a year old when captured on the 28th September, 1941. It was 3 inches long and $\frac{3}{4}$ oz. in weight. Twenty were less than 2 years old, and these provided material for the calculation of their length at the end of the first year only. Twenty-six, under 3 years old, gave figures for the first and second years of their lives. The remainder, eight, were less than 4 years old and gave readings for the length at the

end of the third year. In no case was there any evidence from the scales that any of the fish captured had spawned previously.

The following are average lengths (inches)—

	Glencar L. & Drumcliffe R. combined.	Glencar L.	Drumcliffe R.
1st Year	2·5 (54)	2·3 (44)	3·3 (10)
2nd ,, ...	6·5 (26)	6·4 (20)	7·1 (6)
3rd ,, ...	7·9 (8)	7·9 (8)	—

Figures in brackets are numbers of each group examined.

It would appear that the growth rate of fish taken from Drumcliffe River is superior to that of fish from Glencar Lough.

A comparison of these results with those already published for Lough Corrib (Went 1943) reveals that the growth rate in the Drumcliffe River and Glencar Lough system is somewhat superior to that in the acid tributaries entering Lough Corrib (from the Oughterard direction), as one would expect, but certainly less than those of trout taken from Lough Corrib and its alkaline tributaries. The few fish taken from the Drumcliffe River for the first two years do show growth of the same order as that found in fish from Lough Corrib.

Summary.

(*a*) Material, consisting of satisfactory sets of scales, measurements and weight of 528 salmon taken by netting in the years 1942-45, inclusive, in the Drumcliffe estuary provided the basis of this investigation.

(*b*) During the period under review the captures were fairly evenly divided between the 3 main age groups present, viz., grilse, small spring fish and small summer fish.

(*c*) The great majority of fish taken migrated either as one-year (23·7 per cent.) or two-year smolts (75·9 per cent.). The proportion of one-year smolts (23·7 per cent.) is high.

(*d*) The proportion of previously spawned fish (2·8 per cent.) is low.

(*e*) Calculated average weights were grilse, 6·3 lb., small spring fish, 10·9 lb., and small summer fish, 13·1 lb.

(*f*) There was a gradual rise in the condition co-efficient figure as the season progressed. In the grilse taken in 1942, the figures for the first half of June, second half of June, and July (to the 20th) were 1·19, 1·23 and 1·27, respectively.

(*g*) From scale measurements the lengths of all maiden fish, at the end of each year, were calculated. Fish that grew the fastest migrated earliest. The minimum size of smolts appears to be about 3·3–3·4 inches.

(*h*) At the end of the first sea winter the average length for the grilse is lower than that of the small spring and small summer fish of the same smolt class. At the end of the second year the small spring fish are longer, on the average, than small summer fish.

(*i*) The growth rate of brown trout in the Drumcliffe River and Glencar Lough system, based on measurements of the scales of 55 fish, is compared with the growth rate of brown trout of the Corrib system.

ACKNOWLEDGMENTS.

I am indebted to Dr. A. E. J. Went, Inspector and Scientific Adviser, Department of Agriculture, Fisheries Branch, Dublin, for the interest he has shown in this work, for kind assistance rendered in presentation of the results and for reading through the MSS.

REFERENCES.

Menzies, W. J. M.—

1921—"Salmon of the River Dee." *Fisheries, Scotland*, No. 1.

Went, Arthur E. J.—

1938—"Salmon of the River Shannon." *Proc. Roy. Irish Acad.*, **44**, B. 11.

1940—"Salmon of the River Shannon." *Jour. Dept. Agric.*, Dublin, **37**, No. 2.

1941—"Salmon of the Ballisodare River II—Age and Growth." *Sci. Proc. R. Dublin Soc.*, **22** (N.S.), No. 35.

1941—"Salmon of the Owenduff (Ballycroy) River." *Proc. Roy. Irish Acad.*, **47**, B. 6.

1942—"Salmon of the River Erne." *Sci. Proc. R. Dublin Soc.*, **22** (N.S.), No. 49.

1943—"Salmon of the River Corrib." *Proc. Roy. Irish Acad.* **48**, B. 12.

1943—"Salmon of the River Shannon." *Proc. Roy. Irish Acad.*, **49**, B. 9.

1946—"River Liffey—Survey VII., Salmon of the River Liffey." *Proc. Roy. Irish Acad.*, **51**, B. 2.

1947—"Salmon of the Kerry Blackwater." *Sci. Proc. R. Dublin Soc.*, **24** (N.S.), No. 20.

Went, Arthur E. J. and T. Sankey Barker—

1943—"Salmon and sea trout of the Waterville (Currane) River." *Sci. Proc. R. Dublin Soc.*, **23** (N.S.), No. 9.